National Exams December 2015

98-Pet-A2, Petroleum Reservoir Fluids

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK exam.
3. Any non-communicating calculator is permitted.
4. FIVE (5) questions constitute a complete exam paper.
5. The first five questions as they appear in the answer book will be marked.
6. All questions are of equal value unless otherwise stated and all parts in a multipart question have equal weight.
7. Clarity and organization of your answers are important, clearly explain your logic.
8. Pay close attention to units, some questions involve oilfield units, and these should be answered in the field units. Questions that are set in other units should be answered in the corresponding units.
9. A formula sheet is provided at the end of questions

Question 1 (20 Marks)

Explain (briefly in one or two sentences or a simple equation) the following concepts.

a) Flsah calculations
b) Black-oil
c) Bitumen
d) Dry gas
e) Retrograde condensation
f) Dead oil
g) Live oil
h) Kay's mixing rules
i) Dew point pressure
j) Bubble point pressure

Question 2 (20 Marks)

A PVT cell contains a single-phase natural gas produced from a gas well in a dry gas reservoir at 1400 psia and 200°F. The PVT cell volume is determined to be 12 ft^3. The gas specific gravity is 0.6. Calculate the following:

a) Gas deviation factor, Z,
b) Gas density in lb_{mass}/ft^3,
c) Gas volume at standard conditions (p_{sc}=14.7 and T_{sc}=60°F),
d) Number of mole of gas in the PVT cell.

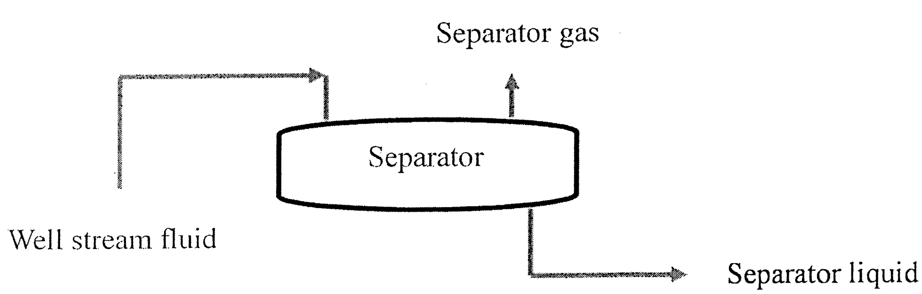
Question 3 (20 Marks)

A separator test has been conducted on a gas well producing from a gas condensate reservoir and the following data have been collected. Use these data and the schematic shown below to find the specific gravity of the produced well stream fluid.

Hint: Use mass of 1STB of oil as a basis. Mass of one STB of water is about 350 lb_{mass}.

Separator producing gas-oil ratio, GOR	40000 SCF/STB
Oil API gravity, API	50
Separator gas specific gravity, γ	0.6
Separator oil molecular weight, Mw	144 lb_{mass}/lb_{mole}

One mole of gas at standard conditions is 379.4 SCF.



Question 4 (20 Marks)

The following PVT data are available from a laboratory test carried out on a black oil sample at 225°F. Use the provided data to calculate:

a) The bubble point pressure of the oil sample
b) The total formation volume factor, B_t at 2682 psia.
c) The coefficient of isothermal compressibility of the oil at 3500 psia.
d) The total formation volume factor, B_t at 800 psia in bbl/STB.

Pressure p(psia)	Oil formation volume factor Bo (bb//STB)	Gas deviation factor Z	Solution gas-oil ratio Rs (SCF//STB)
4500	1.3474	-	632
4000	1.3575	-	632
3500	1.3686	-	632
3000	1.3811	-	632
2682	1.4040	-	632
2500	1.3782	0.8140	584
2200	1.3369	0.8165	509
2000	1.3109	0.8208	460
1800	1.2864	0.8269	414
1600	1.2634	0.8347	369
1400	1.2416	0.8440	326
1200	1.2208	0.8548	285
1000	1.2002	0.8670	245
800	1.1791	0.8808	205
600	1.1566	0.8964	163
400	1.1315	0.9140	119
200	1.1024	0.9339	70

Question 5 (20 Marks)

Gaseous solvents have been used in oil recovery. One important factor in selection of solvent is the amount of solvent required.

a) Calculate the number of mole of solvent (s) required to be mixed with oil (o) in a PVT cell that results in two phase mixture with L=0.8 and V=0.2, where L and V are liquid- and gas-phase fractions. The equilibrium constants (*K*-values) for oil and solvent are estimated from a correlation to be 10 and 0.01, respectively.
b) Determine the equilibrium composition (mole fractions, x_s, x_o, y_s, y_o) of gas and liquid phases in the PVT cell.

Question 6 (20 Marks)

The original reservoir pressure in a gas field was 2500 psia and the reservoir temperature was 190°F. For a gas of the following composition, what would be the reservoir pressure when one-half of the gas has been withdrawn from the reservoir? Assume constant reservoir volume and temperature.

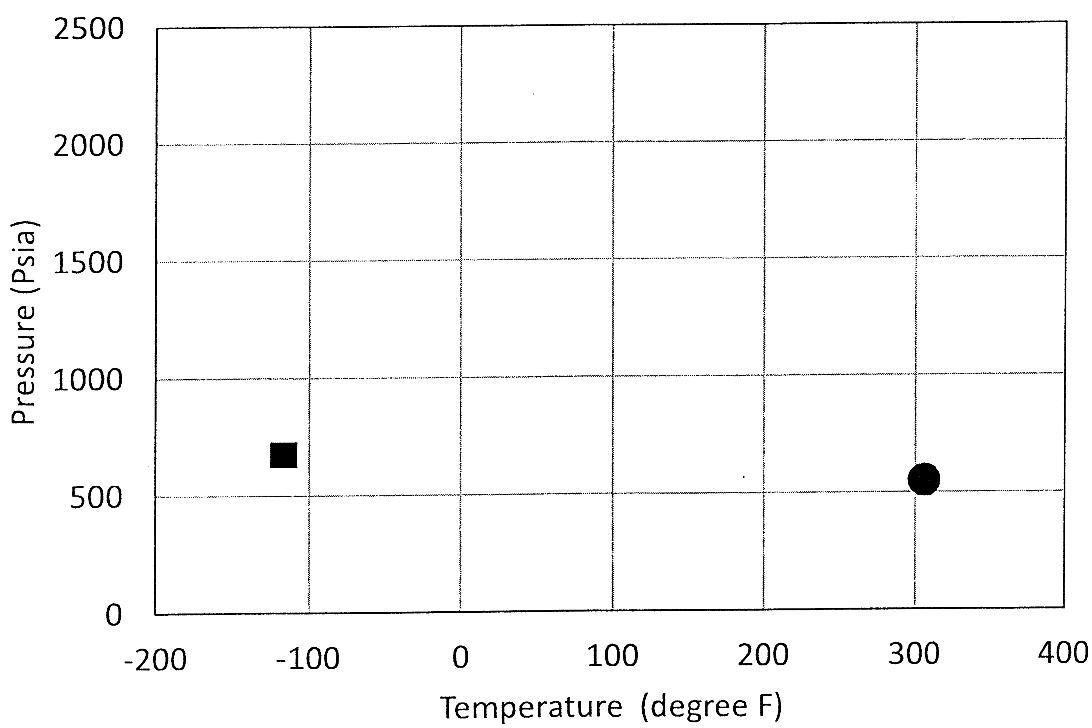
Components	Mole %	Molecular weight (lb_{mass}/lb_{mole})
Methane	91.32	16.04
Ethane	4.43	30.07
Propane	2.12	44.10
Butane	1.36	58.12
Pentane	0.42	72.15
Hexane	0.15	86.18
Heptanes and plus	0.20	104.00

Question 7 (20 Marks)

Critical points of methane (C_1) and normal butane ($n\text{-}C_4$) are shown in the following plot. Use this plot and draw expected approximate pressure-temperature (PT) diagram for pure methane, pure normal butane, and the following mixtures of C_1 and $n\text{-}C_4$

a) Mixture of 80% C_1+20% $n\text{-}C_4$,
b) Mixture of 20% C_1+80% $n\text{-}C_4$.

Hint: Cricondentherm for mixtures of C_1 and $n\text{-}C_4$ can reach as high as 2000 psia.



Formula Sheet

Conversion Factors

1 m^3 = 6.28981 bbl =35.3147 ft^3

1 atm =14.6959488 psi =101.32500 kPa=1.01325 bar

1 m = 3.28084 ft = 39.3701 inch

Real gas law

$pV = ZnRT$

where p in psia, T in °R, V in ft^3, R=10.732 psi-ft^3/(lb$_{mol}$-°R)

Pseudo critical pressure and temperature

$T_{pc} = 168 + 325\gamma_g - 12.5\gamma_g^2 \quad \text{in}\,^oR$

$p_{pc} = 677 + 15.0\gamma_g - 37.5\gamma_g^2 \quad \text{in } psia$

Reduced temperature: $T_r = \dfrac{T}{T_c}$, Reduced pressure: $p_r = \dfrac{p}{p_c}$

where γ_g is the gas specific gravity (Air=1)

Average molecular weight: $M_{av} = \sum y_i M_i$

Pseudo critical Temperature: $T_{pc} = \sum y_i T_{pc_i}$

Reduced temperature: $T_r = \dfrac{T}{T_c}$

Pseudo critical pressure: $p_{pc} = \sum y_i p_{pc_i}$

Reduced pressure: $p_r = \dfrac{p}{p_c}$

Gas density: $\rho = \dfrac{pM}{ZRT}$

where ρ is gas density in lb$_{mass}$/ft^3, p in psia, T in R, M is molecular weight in lb$_{mass}$/lb$_{mole}$ (MW of Air =28.97), R=10.732 psi-ft^3/(lb$_{mol}$-°R)

Gas formation volume factor, $B_g = 0.02827\dfrac{ZT}{p}$ in $\dfrac{\text{ft}^3}{\text{SCF}}$, where p in psia, T in °R.

Total or two-phase formation volume factor: $B_t = B_o + B_g\left(R_{sob} - R_{so}\right)$

Coefficient of isothermal oil compressibility: $c = -\dfrac{1}{B_{ob}}\left(\dfrac{dB_o}{dP}\right)_T$

Phase equilibrium relations:

$$\begin{cases} \sum_i \dfrac{z_i}{1+V(K_i-1)} = 1, & x_i = \dfrac{z_i}{1+V(K_i-1)}, \quad \sum_i x_i = 1, \\ \sum_i y_i = 1, \quad \sum_i z_i = 1, & K_i = \dfrac{y_i}{x_i}, \quad L+V=1 \end{cases}$$

Coefficient of isothermal oil compressibility: $c_g = \dfrac{1}{p} - \dfrac{1}{Z}\left(\dfrac{dZ}{dP}\right)_T$

Oil API gravity:

$API = \dfrac{141.5}{\gamma_o} - 131.5$, where γ_o is oil specific gravity.

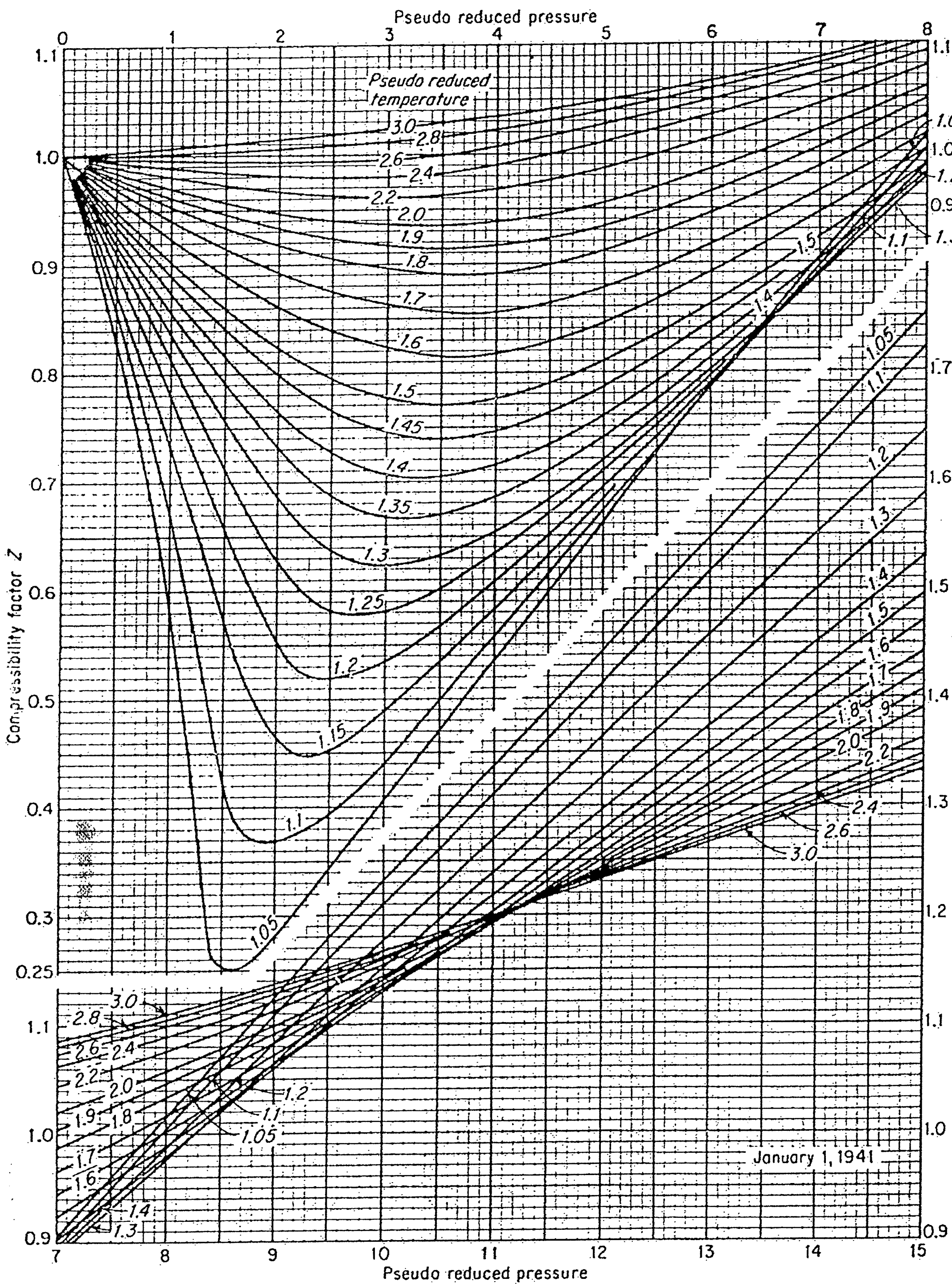


Fig. 4-16. Compressibility factor for natural gases. (*Standing and Katz, 4-87.* Courtesy *AIME.*)